WE CLAIM:

1. A power plant system that can use a fuel that is a gas at ambient temperature and pressure, comprising:

at least one power plant;

at least one fuel storage container; and

at least one expander that can receive fuel from the fuel storage container at a first pressure and provide the fuel to the power plant at a second pressure that is lower than the first pressure.

2. The system according to claim 1, wherein the power plant comprises a fuel cell.

3. The system according to claim 1, wherein the power plant comprises a combustion engine.

4. The system according to claim 1, wherein the fuel storage container is selected from a pressure vessel for holding compressed gas, a pressure vessel for a bed of a gas sorbent, and a dewar for containing a liquefied gas.

5. The system according to claim 2, wherein the fuel storage container holds compressed hydrogen gas or cryogenic liquid hydrogen.

6. The system according to claim 2, wherein the expander is coupled to at least one device selected from a compressor, a pump, an adsorber rotor, or a vehicle propulsion device.

7. The system according to claim 2, wherein the fuel storage container holds cryogenic liquid hydrogen, the power plant system further comprising at least one heat exchanger containing a working fluid, the heat exchanger being juxtaposed with the fuel storage container such that heat can be transferred from the working fluid to the fuel in the fuel storage container.

8. The system according to claim 2, further comprising a first conduit fluidly communicating between the expander and the fuel cell for carrying the fuel, wherein at least a portion of the first conduit is disposed within at least one heat exchanger such that the fuel is a coolant.

9. The system according to claim 1, wherein the fuel comprises hydrogen, methane, natural gas, or propane.

10. A power plant system that can use a fuel that is a gas at ambient temperature pressure, comprising:

at least one power plant;

at least one fuel storage container;

a first conduit fluidly coupling the fuel storage container and the power plant for delivering fuel from the fuel storage container to the power plant; and

at least one regenerative thermodynamic cycle engine thermally coupled to the first conduit such that heat may be exchanged between the fuel and a working fluid for the regenerative thermodynamic cycle engine.

11. The system according to claim 10, wherein the power plant comprises a fuel cell.

12. The system according to claim 10, wherein the power plant comprises a combustion engine.

13. The system according to claim 10, wherein the fuel storage container is selected from a pressure vessel for holding compressed gas, a pressure vessel for a bed of a gas sorbent, and a dewar for containing a liquefied gas.

14. The system according to claim 11, wherein the fuel storage container holds compressed hydrogen gas or cryogenic liquid hydrogen.

15. The system according to claim 11, wherein the regenerative thermodynamic cycle engine is coupled to at least one device selected from a compressor, a pump, an adsorber rotor, or a vehicle propulsion device.

16. The system according to claim 15, wherein the regenerative thermodynamic cycle engine comprises a Stirling engine.

17. The system according to claim 16, further comprising at least one expander fluidly coupled to the first conduit between the fuel storage container and the fuel cell such that the expander can receive fuel from the fuel storage container at a first pressure and provide the fuel to the fuel cell at a second pressure that is lower than the first pressure.

18. The system according to claim 17, further comprising:

at least one first heat exchanger fluidly coupled to the first conduit between the expander and the fuel cell;

at least one pressure swing adsorption module defining an inlet that is in fluid communication with a second conduit for carrying an air feed stream;

wherein at least a first portion of the first conduit and at least a portion of the second conduit are disposed within the first heat exchanger such that heat can be transferred from the air feed stream to the fuel.

19. The system according to claim 18, further comprising a third conduit for carrying the working fluid of the Stirling engine, at least a first portion of the third conduit being disposed within the first heat exchanger such that heat can be transferred from the air feed stream to the working fluid of the Stirling engine.

20. The system according to claim 19, further comprising a second heat exchanger housing at least a second portion of the first conduit and at least a second portion of the third conduit such that heat can be transferred from the working fluid of the Stirling engine to the fuel.

21. The system according to claim 16, further comprising:

a second conduit for carrying an exhaust gas stream from the fuel cell;

a third conduit for carrying the working fluid of the Stirling engine; and

a heat exchanger housing at least a portion of the second conduit and at least a portion of the third conduit such that heat may be transferred from the exhaust gas stream to the working fluid of the Stirling engine.

22. The system according to claim 21, wherein the fuel comprises hydrogen, methane, natural gas, or propane.

23. An electrical current generating system, comprising:

at least one fuel cell;

a fuel storage system; and

means for converting energy from release of fuel from the fuel storage system into mechanical power, heat transfer, or mechanical power and heat transfer.

24. The system according to claim 23, wherein the means for converting energy comprises at least one device selected from an expander, a heat exchanger or a regenerative thermodynamic cycle engine.

25. The system according to claim 24, further comprising at least one gas delivery system that can deliver a gas to the fuel cell, the gas delivery system including at least one mechanically-powered apparatus mechanically coupled to at least one of the expander or regenerative thermodynamic cycle engine.

26. The system according to claim 24, further comprising at least one gas delivery system that can deliver a gas to the fuel cell via a conduit that is thermally coupled to at least one heat exchanger such that heat can be exchanged between the gas and the fuel.

27. An electrical current generating system, comprising:

at least one fuel cell;

at least one hydrogen storage system;

at least one expander that can receive hydrogen from the hydrogen storage system at a first pressure and provide the hydrogen to the fuel cell at a second pressure that is lower than the first pressure; and

at least one oxidant gas delivery system that can produce oxidant-enriched gas for delivery to the fuel cell and that includes at least one device that is coupled to the expander.

28. The system according to claim 27, wherein the oxidant gas delivery system comprises an oxygen gas delivery system that includes a pressure swing adsorption module and the device coupled to the expander is selected from a compressor, vacuum pump, rotary adsorbent bed and rotary adsorber valve.

29. The system according to claim 28, further comprising:

a first conduit for carrying an air feed stream to the pressure swing adsorption module;

a second conduit for carrying the hydrogen from the expander to the fuel cell; and

a heat exchanger housing at least a portion of the first conduit and at least a portion of the second conduit such that heat can be transferred from the air feed stream to the hydrogen.

30. The system according to claim 27, wherein the hydrogen storage system comprises at least one container selected from a pressure vessel for holding compressed hydrogen gas, a pressure vessel for a bed of a hydrogen sorbent, and a dewar for containing liquid hydrogen.

31. The system according to claim 28, wherein the pressure swing adsorption module comprises a rotary pressure swing adsorption module.

32. The system according to claim 28, wherein the hydrogen storage system holds cryogenic liquid hydrogen, the electrical current generating system further comprising:

a first conduit for carrying an air feed stream to the pressure swing adsorption module; and

at least one heat exchanger juxtaposed with the hydrogen storage system such that heat can be transferred from the air feed stream to the cryogenic liquid hydrogen.

33. The system according to claim 27, wherein the expander comprises a multi-stage expander.

34. The system according to claim 27, wherein the expander comprises a positive displacement expander or an impulse turbine.

35. An electrical current generating system, comprising:

at least one fuel cell;

at least one hydrogen storage system;

at least one oxidant gas delivery system that can produce oxidant-enriched gas for delivery to the fuel cell;

a first conduit for carrying an air feed stream to the oxidant gas delivery system; and

at least one Stirling engine thermally coupled to the first conduit such that heat may be exchanged between the air feed stream and a working fluid for the Stirling engine.

36. The system according to claim 35, wherein the oxidant gas delivery system comprises an oxygen gas delivery system that includes a pressure swing adsorption system having at least one device coupled to the Stirling engine.

37. The system according to claim 36, wherein the device coupled to the Stirling engine is selected from a compressor, vacuum pump, rotary adsorbent bed and rotary adsorber valve.

38. The system according to claim 35, wherein the hydrogen storage system comprises at least one container selected from a pressure vessel for holding compressed hydrogen gas, a pressure vessel for a bed of a hydrogen sorbent, and a dewar for containing liquid hydrogen.

39. The system according to claim 36, wherein the pressure swing adsorption module comprises a rotary pressure swing adsorption module.

40. The system according to claim 35, further comprising at least one expander that can receive hydrogen from the hydrogen storage system at a first pressure and provide the hydrogen to the fuel cell at a second pressure that is lower than the first pressure.

41. The system according to claim 40, wherein the expander comprises a multi-stage expander.

42. The system according to claim 40, wherein the expander comprises a positive displacement expander or an impulse turbine.

43. The system according to claim 35, further comprising:

a second conduit for carrying hydrogen from the hydrogen storage system to the fuel cell;

a third conduit for carrying the working fluid of the Stirling engine; and

a heat exchanger housing at least a portion of the second conduit and at least a portion of the third conduit such that heat may be transferred from the hydrogen to the working fluid of the Stirling engine.

44. The system according to claim 40, further comprising:

a second conduit for carrying hydrogen from the hydrogen storage system to the expander;

a third conduit for carrying the working fluid of the Stirling engine;

a fourth conduit for carrying hydrogen from the expander to the fuel cell;

a first heat exchanger housing at least a portion of the second conduit and at least a first portion of the third conduit such that heat may be transferred from the hydrogen to the working fluid of the Stirling engine; and

a second heat exchanger housing at least a portion of the first conduit, at least a second portion of the third conduit and at least a portion of the fourth conduit such that heat may be transferred from the air feed stream to the hydrogen and the working fluid of the Stirling engine.

45. The system according to claim 35, further comprising:

a second conduit for carrying hydrogen from the hydrogen storage system to the expander; and

an orthohydrogen-parahydrogen catalyst bed fluidly coupled to the second conduit.

46. The system according to claim 27, further comprising:

a first conduit for carrying an air feed stream to the oxidant gas delivery system;

a second conduit for carrying the air feed stream to the oxidant gas delivery system;

a third conduit for carrying hydrogen from the hydrogen storage system to the fuel cell;

a fourth conduit for carrying hydrogen from the hydrogen storage system to the fuel cell;

a first heat exchanger housing at least a portion of the first conduit and at least a portion of the third conduit for transferring heat from the air feed stream to the hydrogen;

a second heat exchanger housing at least a portion of the second conduit and at least a portion of the fourth conduit for transferring heat from the air feed stream to the hydrogen;

a first feed air shutoff valve fluidly coupled to the first conduit between the first heat exchanger and the oxidant gas delivery system;

a second feed air shutoff valve fluidly coupled to the second conduit between the second heat exchanger and the oxidant gas delivery system;

a first feed air exhaust valve fluidly coupled to the first conduit between the first heat exchanger and the oxidant gas delivery system;

a second feed air exhaust valve fluidly coupled to the second conduit between the second heat exchanger and the oxidant gas delivery system;

a first hydrogen shutoff valve fluidly coupled to the third conduit between the hydrogen storage system and the first heat exchanger; and

a second hydrogen shutoff valve fluidly coupled to the fourth conduit between the hydrogen storage system and the second heat exchanger.

47. A process for providing fuel to a power plant, comprising:

providing a fuel selected from compressed fuel gas and a cryogenic liquid fuel;

releasing the fuel from a fuel storage system; and

generating mechanical power, a refrigeration effect, or mechanical power and a refrigeration effect from the releasing of the fuel.

48. The process according to claim 47, wherein the generation of the mechanical power, refrigeration effect, or mechanical power and refrigeration effect from the releasing of the fuel comprises:

releasing the fuel from the fuel storage system to provide a compressed fuel gas stream; and

mechanically expanding the compressed fuel gas stream under substantially isentropic conditions.

49. The process according to claim 48, further comprising converting energy from the expansion of the compressed fuel gas stream into mechanical power for driving at least one device selected from a compressor, a pump, an adsorber rotor, and a vehicle propulsion device.

50. The process according to claim 48, wherein the expansion of the compressed fuel gas stream cools the fuel gas stream, the process further comprising:

providing an air feed stream;

transferring heat from the air feed stream to the cooled fuel gas stream resulting in cooling the air feed stream;

introducing the cooled air feed stream into a pressure swing adsorption module to produce an oxygen-enriched gas stream; and

introducing the oxygen-enriched gas stream into the fuel cell.

51. The process according to claim 47, wherein the fuel comprises cryogenic liquid fuel, the process further comprising:

providing an air feed stream;

transferring heat from the air feed stream to the cryogenic liquid fuel such that the air feed stream is cooled and the cryogenic liquid fuel is vaporized into a fuel gas;

introducing the cooled air feed stream into a pressure swing adsorption module to produce an oxygen-enriched gas stream;

introducing the oxygen-enriched gas stream into the fuel cell; and

introducing the fuel gas into the fuel cell.

52. The process according to claim 47, wherein the compressed fuel gas has a pressure of greater than about 100 bars absolute.

53. The process according to claim 47, wherein the fuel comprises hydrogen, methane, natural gas, or propane.

54. A process for providing hydrogen to at least one fuel cell, comprising:

releasing hydrogen from a hydrogen fuel storage system to provide a compressed hydrogen gas stream;

introducing the compressed hydrogen gas stream into at least one expander resulting in a lower-pressure hydrogen gas stream; and

introducing the lower-pressure hydrogen gas stream into a fuel cell.

55. The process according to claim 54, further comprising:

providing an air feed stream;

transferring heat from the air feed stream to the lower-pressure hydrogen gas stream such that the air feed stream is cooled;

introducing the cooled air feed stream into a pressure swing adsorption system to produce an oxygen-enriched gas stream; and

introducing the oxygen-enriched gas stream into the fuel cell.

56. The process according to claim 54, wherein the hydrogen in the hydrogen fuel storage system comprises cryogenic liquid hydrogen, the process further comprising:

providing an air feed stream;

transferring heat from the air feed stream to the cryogenic liquid hydrogen stream such that the air feed stream is cooled and the cryogenic liquid hydrogen stream is vaporized into the compressed hydrogen gas stream;

introducing the cooled air feed stream into a pressure swing adsorption system to produce an oxygen-enriched gas stream; and

introducing the oxygen-enriched gas stream into the fuel cell.

57. The process according to claim 56, further comprising pumping the cryogenic liquid hydrogen to a substantially supercritical pressure.

58. The process according to claim 54, further comprising driving at least one device selected from a compressor, a pump, an adsorber rotor, and a vehicle propulsion device via a mechanical coupling between the device and the expander.

59. The process according to claim 55, wherein the pressure swing adsorption system includes at least one device selected from a pump and a compressor, the process further comprising driving the device via a shaft mechanically coupling the device with the expander.

60. The process according to claim 56, wherein the pressure swing adsorption system includes at least one device selected from a vacuum pump and a compressor, the process further comprising driving the device via a shaft mechanically coupling the device with the expander.

61. A process for providing hydrogen to at least one fuel cell, comprising:

releasing hydrogen from a hydrogen fuel storage system to provide a hydrogen stream;

providing an air feed stream;

providing a regenerative thermodynamic cycle engine having a working fluid;

transferring heat from the regenerative thermodynamic cycle engine working fluid to the hydrogen stream;

transferring heat to the regenerative thermodynamic cycle engine working fluid from at least one of the air feed stream and a fuel cell exhaust gas stream;

introducing the hydrogen stream into the fuel cell; and

introducing the air feed stream into the fuel cell.

62. The process according to claim 61, wherein the regenerative thermodynamic cycle engine comprises a Stirling engine.

63. The process according to claim 62, wherein the hydrogen in the hydrogen fuel storage system comprises cryogenic liquid hydrogen, the process further comprising:

pumping the cryogenic liquid hydrogen to a substantially supercritical pressure;

transferring heat from the Stirling engine working fluid to the cryogenic liquid hydrogen at substantially supercritical pressure resulting in a compressed hydrogen gas stream; and

introducing the compressed hydrogen gas stream into an expander prior to introducing the hydrogen stream into the fuel cell.

64. The process according to claim 62, wherein the hydrogen in the hydrogen fuel storage system comprises compressed hydrogen gas, the process further comprising:

introducing the compressed hydrogen gas stream into an expander after the transferring of heat from the Stirling engine working fluid to the compressed hydrogen gas stream resulting in a cooled hydrogen gas stream; and

transferring heat from the air feed stream to the cooled hydrogen gas stream.

65. The process according to claim 62, wherein the transferring of heat from the air feed stream to the Stirling engine working fluid results in a cooled air feed stream, the process further comprising:

introducing the cooled air feed stream into a pressure swing adsorption system to produce an oxygen-enriched gas stream; and

introducing the oxygen-enriched gas stream into the fuel cell.

66. The process according to claim 65, wherein the pressure swing adsorption system includes at least one device selected from a pump and a compressor and the hydrogen in the hydrogen fuel storage system comprises compressed hydrogen gas, the process further comprising:

introducing the compressed hydrogen gas stream into an expander after the transferring of heat from the Stirling engine working fluid to the compressed hydrogen gas stream; and

driving the pressure swing adsorption system device via a shaft mechanically coupling the pressure swing adsorption device with the expander.

67. The process according to claim 65, wherein the pressure swing adsorption system includes at least one device selected from a pump and a compressor, the process further comprising:

driving the pressure swing adsorption system device via a shaft mechanically coupling the pressure swing adsorption device with the Stirling engine.

68. The process according to claim 62, the process further comprising contacting the hydrogen stream with an orthohydrogen-parahydrogen catalyst.

69. The process according to claim 64, wherein the transferring of heat from the air feed stream to the cooled hydrogen gas stream results in a cooled air feed stream, the process further comprising:

introducing the cooled air feed stream into a pressure swing adsorption system to produce an oxygen-enriched gas stream; and

introducing the oxygen-enriched gas stream into the fuel cell.

70. The system according to claim 4, wherein the fuel storage container comprises a pressure vessel that includes a bed of a physical adsorbent.

71. The system according to claim 70, wherein the adsorbent is selected from a carbon material and a zeolite.

72. The system according to claim 4, wherein the fuel comprises hydrogen and the fuel storage container comprises a pressure vessel that includes a bed of hydride forming metal or metallic alloy.

73. The system according to claim 10, wherein the working fluid for the regenerative thermodynamic cycle engine is substantially identical to the fuel gas.

74. The system according to claim 10, wherein the working fluid for the regenerative thermodynamic cycle engine and the fuel gas comprise hydrogen.

75. The system according to claim 13, wherein the fuel storage container comprises a pressure vessel that includes a bed of a physical adsorbent.

76. The system according to claim 75, wherein the adsorbent is selected from a carbon material and a zeolite.

77. The system according to claim 13, wherein the fuel comprises hydrogen and the fuel storage container comprises a pressure vessel that includes a bed of hydride forming metal or metallic alloy.

78. The system according to claim 2, further comprising:

a first conduit for carrying an exhaust gas stream from the fuel cell; and

at least one heat exchanger juxtaposed with the fuel storage container such that heat can be transferred from the exhaust gas stream to fuel in the fuel storage container.

79. The process according to claim 61, further comprising intermittently transferring heat from the hydrogen stream to the regenerative thermodynamic cycle engine working fluid.

80. The system according to claim 29, further comprising a third conduit bypassing the heat exchanger for carrying the air feed stream to the pressure swing adsorption module.